

We claim:

- 1 1. An optical device, comprising:
2 a substrate having a plurality of channels therethrough;
3 a plurality of shutters, with respective shutters associated with respective
4 channels in the substrate; and
5 a plurality of lenses, each lens having a body portion and a head portion,
6 with respective body portions of the lenses disposed in respective channels of
7 the substrate.
- 1 2. The optical device of claim 1, wherein the plurality of lenses comprise a
2 polymer material.
- 1 3. The optical device of claim 1, wherein the plurality of lenses comprise an
2 oxide film material.
- 1 4. The optical device of claim 1, wherein the plurality of lenses comprise a
2 nitride film material.
- 1 5. The optical device of claim 1, the substrate having a first refractive index
2 and the plurality of lenses having a second refractive index, wherein the first
3 refractive index is less than the second refractive index.
- 1 6. A method, comprising:
2 forming a substrate with a plurality of channels therethrough; and
3 forming a lens array on the substrate with each lens self-aligned with a
4 respective channel in the substrate.
- 1 7. The method of claim 6, further comprising:

2 spinning a polymer on the substrate, wherein the polymer fills the
3 channels and accumulates outside the substrate.

1 8. The method of claim 7, further comprising:
2 positioning a plurality of masks over the accumulated polymer, wherein
3 each mask is disposed between channels of the image array; and
4 exposing the polymer to radiation, producing unexposed polymer and
5 exposed polymer.

1 9. The method of claim 8, further comprising:
2 bathing the polymer in a solvent, causing the unexposed polymer to
3 dissolve away.

1 10. The method of claim 9, further comprising:
2 heating the exposed polymer until the exposed polymer assumes a convex
3 shape.

1 11. A method, comprising:
2 depositing an oxide film on a substrate, the substrate having a plurality of
3 channels, wherein the oxide film fills the plurality of channels from a first end to
4 a second end and accumulates outside the second end of the substrate; and
5 positioning a plurality of masks over the oxide film, wherein each mask is
6 disposed over one of the plurality of channels, the plurality of masks being
7 graded in a convex shape.

1 12. The method of claim 11, further comprising:
1 plasma-etching the oxide film, separating the oxide film into a plurality of
2 oxide film portions, one for each channel, wherein the oxide film portions are
3 substantially convex-shaped.

- 1 13. A method, comprising:
2 depositing a nitride film on an image array, the image array comprising a
3 substrate with a plurality of channels, wherein the nitride film fills the plurality of
4 channels and accumulates outside the image array; and
5 positioning a plurality of masks over the nitride film, wherein each mask is
6 disposed over one of the plurality of channels, the plurality of masks being
7 graded in a convex shape.
- 1 14. The method of claim 13, further comprising:
2 plasma-etching the nitride film, such that a plurality of nitride film portions
3 remain on the image array, one for each channel, wherein the nitride film
4 portions are substantially convex-shaped.
- 1 15. An optical device, comprising:
2 a diffraction grating, comprising a plurality of channels disposed within a
3 substrate, the channels having a predetermined shape; and
4 a microlens array, comprising a plurality of microlenses, wherein each
5 microlens comprises a head portion and a body portion, the head portion being
6 convex and the body portion having the predetermined shape, the microlens
7 array being self-aligned with the diffraction grating;
8 wherein the body portion of each microlens of the plurality of microlenses fits
9 into one of the plurality of channels and the head portion of each microlens of
10 the plurality of microlenses extends outside a second end of the substrate.
- 1 16. The optical device of claim 15, wherein the head portion of a first
2 microlens touches the head portion of an adjacent microlens.
- 1 17. The optical device of claim 16, wherein the microlens array comprises a
2 polymer material.

1 18. The optical device of claim 16, wherein the microlens array comprises an
2 oxide film.

1 19. The optical device of claim 16, wherein the microlens array comprises a
2 nitride film.

1 20. The optical device of claim 16, wherein the substrate has a first refractive
2 index and the microlenses of the microlens array have a second refractive index
3 and the first refractive index is smaller than the second refractive index.

1 21. The optical device of claim 20, further comprising:
2 a light source for sending light rays toward the diffraction grating, to be
3 received by the head portion of each microlens, the light rays comprising first
4 light rays, second light rays, and third light rays;
5 wherein the first light rays travel within the channel boundary and are received
6 into the channel and the second light rays travel within the active pixel region,
7 but outside the channel boundary, and are refracted by the microlens and
8 received into the channel.

1 22. The optical device of claim 21, wherein the third light rays travel outside
2 the active pixel region, are refracted by the microlens, but are reflected off the
3 substrate as fourth light rays.

1 23. The optical device of claim 22, wherein some of the fourth light rays are
2 reflected by the microlens back into the channel according to the principle of
3 total internal reflection.

1 24. A system, comprising:
2 a light source; and

3 an image array positioned to receive light from the light source, wherein
4 the image array includes a self-aligned microlens array formed thereon.

1 25. The system of claim 24, the image array further comprising a substrate
2 having a plurality of channels formed therethrough, the substrate having a first
3 refractive index.

1 26. The system of claim 25, the self-aligned microlens array further
2 comprising a plurality of lenses, one for each channel of the image array, each
3 lens having a head portion and a body portion, wherein the body portion
4 completely fills its respective channel.

1 27. The system of claim 26, wherein the self-aligned microlens array has a
2 second refractive index, wherein the first refractive index is less than the second
3 refractive index.